REVERSAL-NONREVERSAL SHIFT PERFORMANCE IN CHIMPANZEES

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James Charles Domangue, Jr.

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REVERSAL-NONREVERSAL SHIFT PERFORMANCE IN CHIMPANZEES

Approved:

R. K. Davenport, Chairman

Anderson D. Smith

James Gough, Jr.

Date approved by Chairman: 25 Nov. '74

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SUMMARY

Recent studies have shown that qualitative differences on perceptual and cognitive learning tasks exist between apes and monkeys. Apes, particularly chimpanzees, have been shown superior to monkeys on some learning tasks (e.g. discrimination learning sets and the transfer index). Chimpanzees have demonstrated a capacity to integrate information across sensory modalities, while no evidence for this capacity in monkeys has been obtained. It has been shown that chimpanzees are capable of language-like behaviors, while such has not been shown in monkeys. Early restricted environments have no effect on later cognitive abilities in monkeys, while chimpanzees show deficits in a variety of conceptual areas when reared in restricted environments.

Findings regarding one particular cognitive learning task, the reversal-nonreversal shift problem, have been of interest because of differences found in the performance of human and nonhuman subjects on this task. Nonhuman animals, such as rats, chickens and monkeys, perform better on nonreversal shift problems while human adults do better on the reversal shift problems. A developmental trend also occurs in humans. Kindergarten children perform better on nonreversal shift problems and performance on reversal problems improves with age until it becomes superior to nonreversal shift performance in the adult.

Differences in performance of chimpanzees and monkeys on a variety of cognitive problems suggests that chimpanzees might perform differently than monkeys on the reversal-nonreversal shift problem.

For this reason chimpanzee performance on the reversal-nonreversal shift problem was investigated.

The results showed that chimpanzees, like other nonhuman organisms, performed better on nonreversal shift problems. This finding further supports the mediational model of reversal-nonreversal shift performance, and is consistent with the notion that human performance on this task is influenced by the presence of language.

CHAPTER I

INTRODUCTION

One fruitful approach to the study of comparative behavior is to compare the behaviors of animals who have evolved from a common ancestor. Similarities and differences between the behaviors of animals that are descendants of a common ancestor are important in understanding evolutionary trends (Hodos & Campbell, 1969). Present-day species presumably retain some of the behavioral characteristics of their ancestors and thus provide clues to their evolutionary lineage. Similarities and differences between animals who share many behavioral and morphological characteristics provide evidence about changes that have occurred during evolution.

Members of the mammalian order primates include man, apes, monkeys, and prosimians. It appears from paleontological and morphological evidence that man shares an ancestry with the other primate species which other animals do not share (Young, 1962). Man is perhaps more closely related to the Great Apes (chimpanzees, *Pan troglodytes*, orang-utans, *Pongo pygmaeus*, and gorillas, *Gorilla gorilla*) than to the other primates since they are thought to share an ancestor not common to the other primates. This common ancestry would imply that the study of nonhuman primates, especially the Great Apes, is important to the understanding of man.

This thesis investigates the performance of chimpanzees on a particular concept formation task, the reversal-nonreversal shift problem, so that this performance can be compared with that of other primates, specifically man and monkeys. This introduction will examine the performance of monkeys and apes on certain conceptual and perceptual tasks. The performance of monkeys and apes on concept formation tasks will be treated more specifically with special emphasis given to the reversal-nonreversal shift problem and related research findings. Finally the purpose and rationale of the present study will be set forth.

Cognitive and Perceptual Abilities of Monkeys and Apes

In a number of areas involving complex cognitive and perceptual abilities apes have been shown to be superior to other nonhuman primates. For example, there are qualitative differences between apes and monkeys with regard to their ability to integrate information across sensory modalities. Chimpanzees also seem to be able to recognize their image in a mirror, while monkeys do not. Chimpanzees are capable of exhibiting rudimentary elements of natural language such as syntactical arrangement, class and object concepts, and interrogatives. Such abilities have not been demonstrated in monkeys. In addition, chimpanzees perform better than monkeys on some learning tasks such as learning sets and the transfer index. A related finding which also suggests qualitative differences between apes and monkeys is that early impoverished rearing is associated with impaired performance on learning tasks later in life in chimpanzees, but not in monkeys. Of course, there are many learning tasks on which apes and monkeys have not been compared. In the following sections the differences between ape and monkey performance on various perceptual and cognitive tasks will be examined in detail.

Cross-Modal Perception

One area in which apes have been shown to possess superior perceptual abilities as compared to monkeys is cross-modal perception, that is, the ability to integrate information across sensory modalities. Research in this area has been conducted to determine which species are capable of using information presented in two different sensory modalities (e.g. vision and touch) to solve a problem. Two different experimental approaches have been employed in investigating cross-modal perception. These are the transfer of training paradigm and the matching-to-sample paradigm. While it has been shown that apes are capable of integrating information across sensory modalities, the research findings in this area suggest that monkeys do not possess this ability.

Early researchers in this area used the transfer of training paradigm to investigate cross-modal perception in monkeys. This procedure required that subjects learn to discriminate between the objects presented in one modality, for example, touch. Following criterion performance on this initial discrimination, the same objects were presented in a new modality, for example, vision. If the discrimination in the second modality was learned in fewer trials than in the first modality, this result was taken, by some investigators, to indicate that the subject possessed cross-modal perceptual ability. While some researchers reported positive results using this procedure (Klüver, 1936; Stepien & Cordeau, 1960; Wilson & Wilson, 1962; Wilson & Shaffer,

1963) others reported negative evidence for cross-modal transfer in monkeys (Ettlinger, 1960; Burton & Ettlinger, 1960; Blakeslee & Gunter, 1966; Rothblatt & Wilson, 1968). The negative results led some to speculate that language was the necessary basis of cross-modal perception and, therefore, that nonhuman organisms would not exhibit the phenomenon (Ettlinger, 1967).

In addition to the inconsistent findings, there was a methodological problem with the transfer of training paradigm employed in these studies. Since the stimuli were presented several times in each modality, subjects were not forced to equate stimuli across modalities. Better performance in the second modality might have occurred because discriminations in that modality may have been easier to learn than discriminations in the first modality. The only evidence that would have indicated that the subject truly identified an object presented in one modality as being the same as an object previously presented in a different modality would have been data which represented the animal's first encounter with that object in the new modality. An unequivocal demonstration of cross-modal perception would require that the subject learn to choose an object presented in one modality and then correctly select from the two alternatives an identical object presented in another modality _for the first time_. This procedure has recently been used to study the cross-modal perceptual abilities of apes. The results indicated that chimpanzees and orang-utans do exhibit cross-modal transfer.[1] This procedure has not as yet been attempted with monkeys.

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[1]R. K. Davenport, personal communication, June 5, 1974.

Cross-modal perceptual abilities have also been investigated by using a cross-modal matching-to-sample paradigm involving unique problems on each trial. In this procedure a unique object, that is, one that the subject is not familiar with, is presented in one modality. At the same time an identical object and another unique object are presented to the subject in another modality. The subject selects one of these and is rewarded if he selects the object which is identical to the object presented in the other modality. Using this procedure apes have been shown to possess cross-modal perceptual abilities (Davenport & Rogers, 1970; Davenport & Rogers, 1971; Davenport, Rogers, & Russell, 1973) thus indicating that language is not the only basis for cross-modal perception. This technique has also been applied to monkeys, and to date the phenomenon has not been demonstrated in rhesus monkeys (*Macaca mulatta*) or African green monkeys (*Cercopithecus aethiops*) (See footnote 1). A similar matching-to-sample procedure involving repeated trials, and using non-unique objects, has also been used with monkeys. Thus far, no evidence for cross-modal abilities in monkeys has been reported (Ettlinger & Blakesmore, 1967; Milner, 1973). These results suggest qualitative differences between apes and monkeys in regard to this perceptual ability.

Self-Recognition

Gallup (1970) has reported that chimpanzees were able to learn to recognize their own reflections while monkeys were not. After 10 days of prolonged (8 hours per day) exposure to mirrors 4 chimpanzees were anesthetized and then marked with a red alcohol-soluble dye above one eyebrow and on the top half of the opposite ear. Following recovery from anesthesia, each animal was observed for 30 minutes to determine the number of times any marked part of the skin was touched spontaneously without the mirror present. Afterward the mirror was reintroduced and the number of times marked parts of the skin were touched was again recorded. While almost no mark-directed responses occurred when the mirror was absent, the frequency of such responses increased significantly after the mirror was reintroduced. Monkeys tested in the same fashion showed no marked-directed responses after 14 days of prolonged (12 hours per day) mirror exposure. These results suggest that qualitative differences exist between monkeys and apes in their ability to recognize their own reflected image.

Learning Set Problems

Chimpanzees have been shown to perform better than rhesus monkeys on learning set problems. The learning set paradigm, as devised by Harlow (1949), is simply a series of different discrimination problems, each of which is presented for some set number of trials. Several types of discrimination problems can be used including simple object discrimination, positional (left-right) discrimination, oddity problems, or discrimination reversals. The dependent variable of interest is the percentage of correct trials on successive discrimination problems. Monkeys show a gradual improvement in performance on successive problems until approaching 100% correct performance. However, chimpanzees make less errors than monkeys on initial problems and reach asymptotic performance in significantly fewer trials than do monkeys on simple discrimination learning set problems (Hayes, Thompson, & Hayes, 1953).

Transfer Index

Chimpanzees have also performed better than monkeys on the transfer index which was developed by Rumbaugh (1971) as a measure of "comparative intelligence." This measure involves equating groups of animals on initial mastery of a two-choice visual discrimination task, followed by testing for transfer of training on the reversal of the initial discrimination. The animals are equated for mastery of initial discrimination by training them to a specific criterion level. The transfer index measure is the mean ratio of correct percentage on the reversal trials (trial 1 is deleted) to the criterion used on the initial discrimination. Rumbaugh (1971) has reviewed the relevant literature concerning chimpanzee performance on the transfer index in addition to other learning tasks such as simple discrimination and learning sets. Based on this review, he concluded that apes possess superior learning skills when compared with other nonhuman primates.

Restricted Rearing Effects

Another line of research that suggests qualitative differences in the intellectual functioning of primates is the effect of early impoverished rearing on later performance on learning tasks. Harlow and his associates (Harlow, Harlow, Schiltz, & Mohr, 1971) have reported that rhesus monkeys reared in an impoverished environment are not inferior to animals given standard laboratory rearing on learning tasks such as simple discrimination, delayed response, learning set and oddity problems. In chimpanzees, however, early restricted environments are associated with a variety of deficits in performance on cognitive tasks (delayed response, learning sets, oddity, and transfer index) later in life (Davenport & Rogers, 1968; Davenport, Rogers, & Menzel, 1969; Rogers & Davenport, 1971; Davenport, Rogers, & Rumbaugh, 1973).

Language-Like Behavior

An additional example of chimpanzee cognitive ability has been the recent demonstration of language-like behavior. The Gardners (Gardner & Gardner, 1969) and Premack (1970; 1971) have demonstrated basic linguistic phenomena, such as symbolization, syntax, object and class concepts, negation, and interrogatives, in their chimpanzees. Rumbaugh and his associates (Rumbaugh, Gill, & Von Glasersfeld, 1973) are attempting to teach an artificial language to a chimpanzee through careful arrangement of specific response contingencies. So far, they have reported that the animal has demonstrated reading and sentence completion skills. At this time there is no evidence available suggesting that monkeys possess such abilities.

Concept Formation Studies of Apes and Monkeys

The area of concept formation is one of special interest in the general area of learning processes. Concept formation studies aim at discovering the basic processes and relationships that an organism uses in categorizing aspects of the physical environment. Some of the studies of concept formation in apes and monkeys are reviewed in this section.

Studies of concept formation in monkeys include the work of Brown and his associates (Brown, Overall, & Gentry, 1958; Brown, Overall, & Blodgett, 1959) who demonstrated that rhesus monkeys can learn to respond on the basis of novelty. The procedure involved presenting stimulus pairs which consisted of one new object and one object retained from the immediately previous problem. In the first study, the new object was the unrewarded member of the pair. In the later study, the new object was unrewarded in the first half of the problems, and rewarded in the second half for one group of animals, and vice-versa for another group. First trial errors (each problem consisted of four trials) decreased steadily and reliably in both conditions. Other investigators have found that rhesus monkeys can solve discrimination problems on the basis of concepts of shape (Andrew & Harlow, 1948), number (Hicks, 1956), and size (Klüver, 1933). Stone (1961) also reported that rhesus monkeys could attain concepts of color, form, and size with extended training. Squirrel monkeys (Saimiri sciurens) can solve simple concept problems in addition to problems based on conjunctive and disjunctive concepts, in which two dimensions are relevant to the correct solution of the problem (Wells & Deffenbacker, 1966, 1967).

In addition, Bernstein (1961) has devised a method of testing apes and monkeys for their ability to perform on the basis of dimension-abstracted oddity. Five different stimulus objects were presented, four of which were identical on a given relevant dimension, while the positive (reinforced) object was different with respect to the relevant dimension. The set of stimulus objects varied from trial to trial, while the relevant dimension remained the same. Using this technique, it was shown that chimpanzees, orang-utans, pig-tailed macaques (Macaca nemestrina), and rhesus monkeys could all solve oddity problems based on size, brightness, number and color.

A number of concept formation studies have been conducted on chimpanzees. For example, chimpanzees have been shown to be able to respond on the basis of dimension-abstracted sameness (Robinson, 1955, 1960). In this problem, two pairs of objects are presented, the objects in the positive pair being identical to each other, while the objects in the negative pair are different from each other. The animals are then tested for transfer of the sameness concept to new pairs of objects. Spence (1936, 1938, 1942) carried out several experiments aimed at determining the conditions under which chimpanzees respond to abstract relationships based on size. He found that relational responding in chimpanzees depended on the size ratios of the training stimuli and on whether the problem involved two or three stimuli. Kelleher (1958) has shown that chimpanzees can solve problems on the basis of specific patterns, and to more abstract stimuli in which a common pattern element is involved. More recently, investigators have shown that chimpanzees can perform on the basis of the abstract concept of middleness (Rohles & Devine, 1966, 1967).

The Reversal-Nonreversal Shift Problem

Findings regarding reversal and nonreversal shift problems in concept formation experiments have been of particular interest because of differences found in the performance of human and nonhuman subjects on this task. As seen in Figure 1 the paradigm for these problems involves first having a subject learn a discrimination on the basis of a given dimension, such as brightness (e.g. black is correct, white is incorrect) when the stimuli vary on two or more dimensions. Then, after reaching a certain level of performance cue values of the problem are changed. In a reversal shift, the same dimension is relevant, but

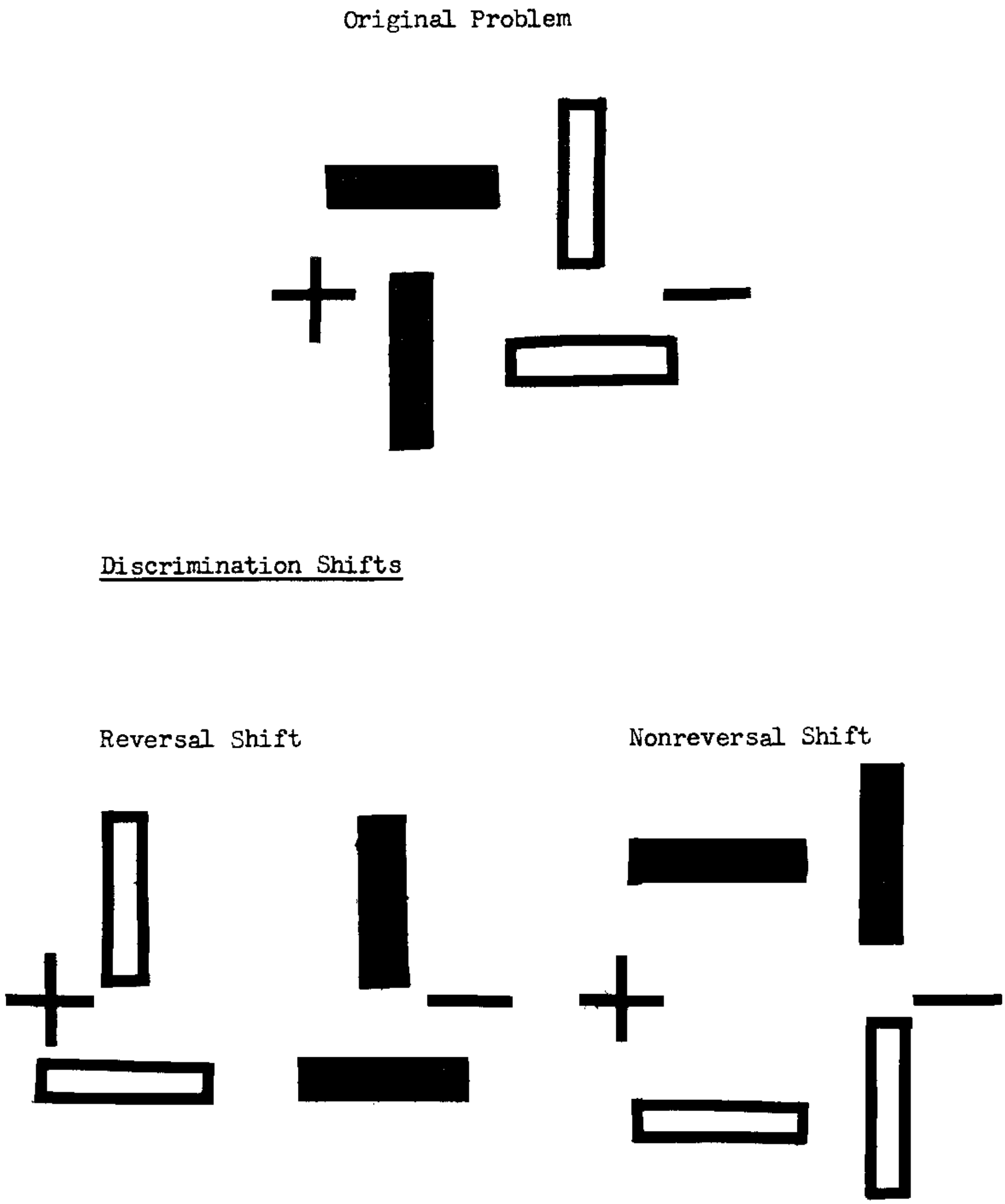

Figure 1. The Reversal-Nonreversal Shift Paradigm

the correct solution is opposite the previously correct solution (e.g. where black was correct and white was incorrect, now black is incorrect and white is correct). Thus the solution is reversed in a reversal shift problem. In a nonreversal (also called extradimensional) shift problem another dimension becomes relevant. That is, the basis of the solution is no longer the previously relevant dimension, but is now a dimension which was previously irrelevant (e.g. whereas black was correct previously, orientation is now the relevant dimension, and brightness is irrelevant).

There are differences between human and nonhuman subjects with regard to reversal and nonreversal shift performance. A variety of animals, such as rats, chickens, and monkeys, show better performance on nonreversal problems than on reversal shift problems (Mackintosh, 1962; Brookshire, Warren, & Ball, 1961; Tighe, 1964) while human adults show superior performance on the reversal shift problem (Kendler & D'Amato, 1955). Within human subjects there is also a developmental trend. Nursery school children show superior performance on the nonreversal problems, and with age there is a gradual change in this relationship until it reverses so that older children perform better on the reversal problem (Kendler & Kendler, 1970).

To account for these diverse results, Kendler (1971) proposed a mediational stimulus-response model. He postulated that the adult subject's overt response is mediated by a covert verbal response to the stimulus. For example, size or color could serve as mediating responses to a large-small or a red-green discrimination. As language develops in the child, the tendency to use such verbal mediators increases, thus accounting for the developmental trend as well as the difference between human and nonhuman performance. Kendler and his associates (Kendler, Kendler, & Wells, 1960) also suggest that children go through a period during which verbal responses appropriate to the relevant dimension are available, but do not serve as mediators between the external stimuli and the overt responses. That is, the child, at a certain stage in his development, can use such terms as black, white, color, etc., but such verbal responses fail to control overt responses in conceptual problems. Such a failure is termed a mediational deficiency (Kendler, 1972).

The mediational hypothesis is supported by several studies. Kendler, Glasman, and Ward (1972) found that pretraining with verbal labels had significant effects on reversal shift performance in preschool children. Subjects who were taught to use common labels for stimuli (curvy or pointy for curved or rectilinear lines) performed better on reversal shift problems than subjects taught only to attend to the essential characters of the stimuli, and control subjects who were given no special pretraining. In addition, Kendler, Kendler, and Sanders (1967) compared reversal and half-reversal shift performance in college students. Stimuli were either conceptually related words or unrelated consonant trigrams. The procedure involved having subjects sort stimuli into predetermined categories. After learning the original sorting classification, subjects were required to learn a new classification, in which either half the stimuli were classified opposite to their original classification (half-reversal shift) or all the stimuli were given a classification opposite the original classification (reversal shift). When conceptually related stimuli were used, the reversal shift was executed more quickly. However, when unrelated trigrams served as stimuli, reversal and half-reversal shift performance were not significantly different. Since consonant trigrams are essentially meaningless, verbal mediation is presumably greatly reduced when they are used as stimuli. The mediational hypothesis is therefore further supported by the finding that in adult subjects, reversal shift performance is disrupted relative to performance on half-reversal shifts.

Studies of transposition which indicate that verbal mediation increases with age provide further evidence in support of the mediational model. Transposition problems involve training a subject on a discrimination problem which can be based on either an absolute or a relative cue, followed by presentation of test stimuli to determine which cue, absolute or relative, controls the subject's response. Size is often used as the relevant dimension in transposition problems. The paradigm for the two-stimulus transposition problem is presented in Figure 2. Two stimuli, identical except for size, are presented to the subject. In the original discrimination, the reward might be given for choosing the larger object, for example, After the subject reaches criterion performance on this discrimination, a test problem involving two new objects is presented. The smaller of the two new objects is relatively close in size or equal to the previously correct object. It can thus be determined if the subject's response is to relative or absolute cues. If the subject responds to the object which is closer or equal in size to the previously correct object, his response is to absolute, or "stimulus bound" cues. If he responds to the new larger object, he is responding relationally. Relational responding is also termed "transposition."

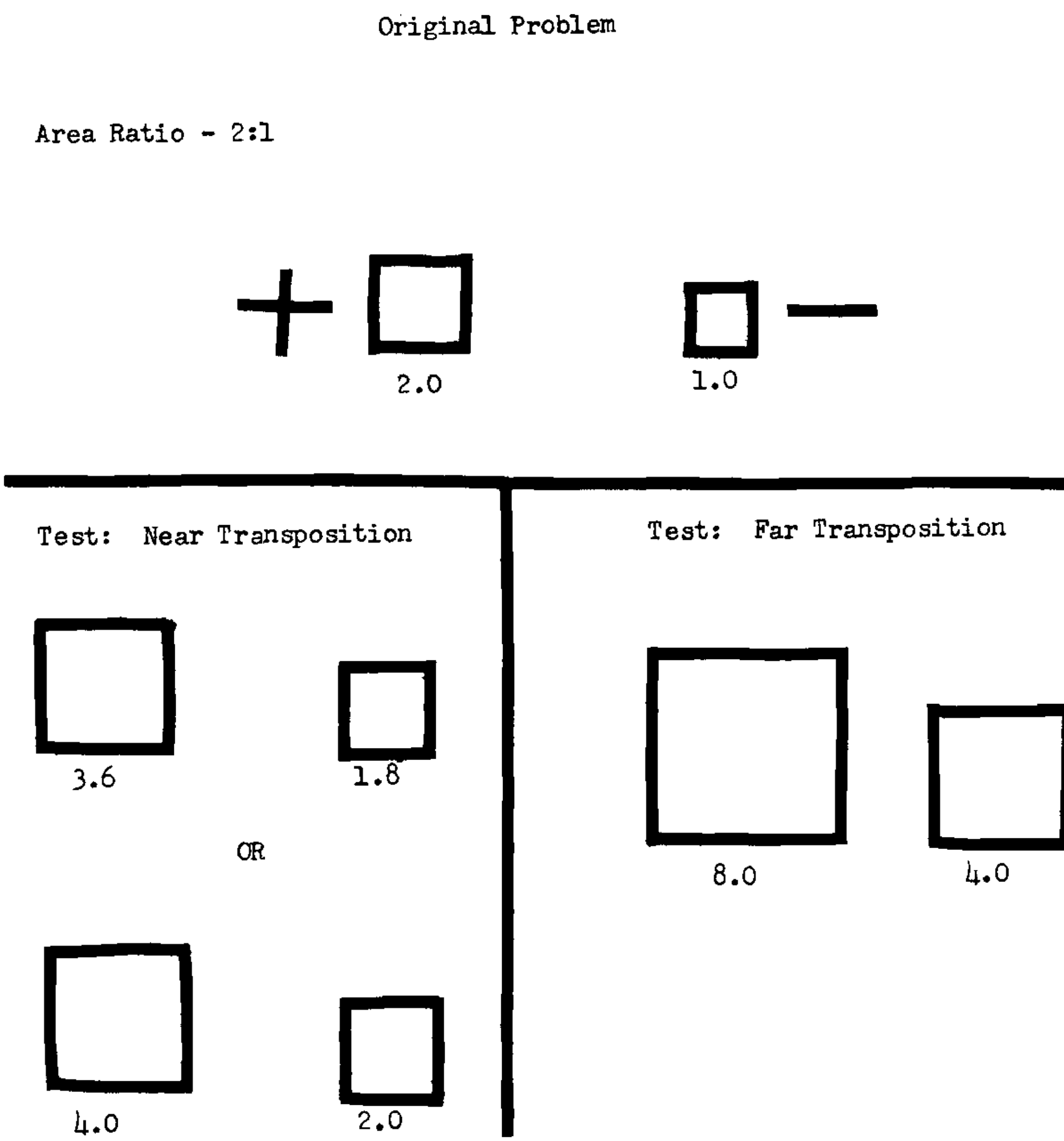

Figure 2. Two-Stimulus Transposition

The test stimuli in the transposition problem can be relatively similar in size to the training stimuli, in which case the problem is termed "near" transposition. If the test stimuli are relatively dissimilar in size to the training stimuli, the problem is termed "far" transposition. Early studies of two-stimulus far-transposition have shown that the frequency of relational responding increases with age in young children (Kuenne, 1946; Alberts & Ehrenfreund, 1951). Since the transposition response in this instance reflects the concept of relative size (i.e. bigger, smaller), this concept may serve as a mediator for older children.

Studies of a different version of the transposition task, the intermediate size problem, also indicate age changes in verbal mediation. This problem involves presenting three stimulus objects together instead of two, with a reward being given for choosing the middle-sized object. Using this task Reese (1962a) found that younger (preschool) children transposed only when the area ratio of the stimuli was relatively small (1.69:1.3:1) while older (kindergarten) children transposed when the area ratio of the stimuli was relatively large (4:2:1) as well. It can be seen from Figure 3.that when the area ratio of the stimuli is small, the objects in a given discrimination are more nearly equal to one another in size than when the area ratio of the stimuli is large. It has been suggested that when the area ratio of the stimuli is small, transposition does not require mediation, because the objects are less easily discriminated from each other. On the other hand, transposition would require mediation if the area ratio is large, since the objects are readily discriminable from one another (Stevenson & Bitterman, 1955). Thus the

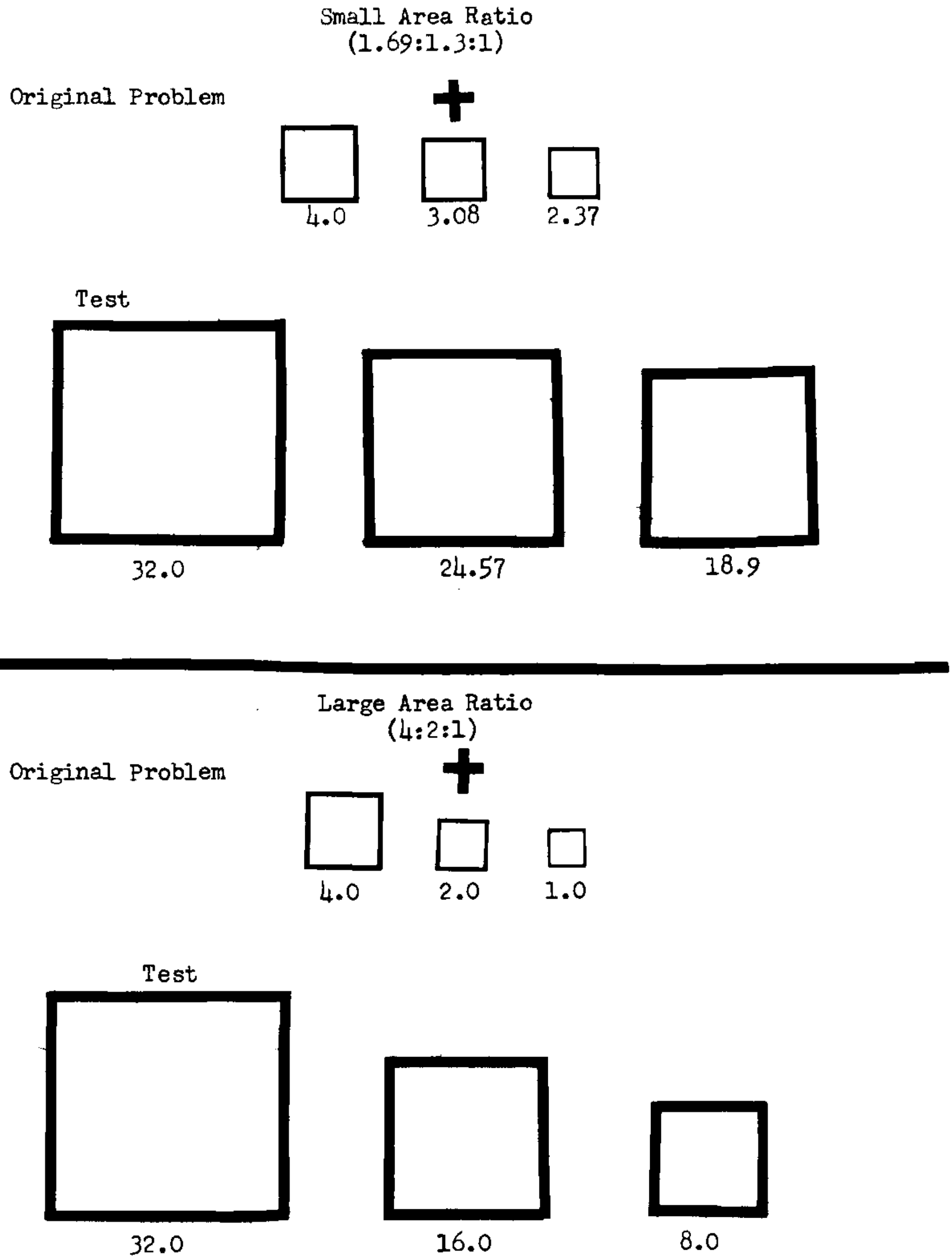

Figure 3. Intermediate Size Problem - Far Transposition

finding that older children transpose when mediation is required, while younger children do not, supports the mediational deficiency notion. Rudel's (1960) finding that the ability of a preschool child to verbalize the middle-size concept is not related to his performance on the intermediate-size task gives further support to the hypothesis.

<u>Chimpanzee Performance on the Reversal-Nonreversal Shift Problem</u>

The previously discussed superiority of chimpanzees to monkeys on various cognitive tasks raises a question regarding their performance on the reversal-nonreversal shift problem. In view of the superior performance of chimpanzees on these tasks, and in light of the common ancestry of apes and man, it would be of particular interest to investigate the chimpanzee's performance on the reversal-nonreversal shift problem. Since chimpanzees do not ordinarily exhibit natural language, one might suppose that chimpanzees perform similarly to monkeys on this task. As noted before, however, a similar hypothesis, that cross-modal perception was dependent on language capability, was disconfirmed by demonstrating the phenomenon in the chimpanzee (Davenport, Rogers, & Russell, 1973).

On the other hand, if chimpanzees perform similarly to humans the mediational theory would have to be examined very closely since chimpanzees, unlike humans, do not ordinarily exhibit natural language. This does not mean to imply that mediational theorists (e.g. Kendler) would support the notion that a mediating response must necessarily be verbal. In fact there are ways to improve reversal shift performance in nonhuman subjects. Overtraining on the original discrimination problem produces a cross-over effect so that reversal shift performance is superior to nonreversal shift performance in rats (Mackintosh, 1962). Also, repeated presentations of reversal problems are associated with a marked improvement in performance on the reversal problem in monkeys (Harlow, 1949) and rats (Dufort, Guttman, & Kimble, 1954). These effects could be explained in a mediational framework by postulating a nonverbal mediator. If chimpanzees perform similarly to humans on the reversal-nonreversal shift problem such a nonverbal mediator would also be necessary to explain chimpanzee performance within the framework of the mediational model.

The problem remains, however, that chimpanzee performance is difficult or impossible to predict from the performance of other animals. Nonhuman animals show a tendency to do better on nonreversal shifts. If chimpanzees also show superior performance on the nonreversal shift problem, the mediational model would be further supported. If, however, chimpanzees do not perform similarly to other nonhuman animals, the mediational hypothesis might need to be re-evaluated. If chimpanzees do equally well on both types of shifts, or if they perform better on reversal shift problems, as do human adults, the role of verbal mediation in the conceptual shift problem would be questioned. For this reason, and because chimpanzees show qualitative differences in performance on other cognitive and perceptual problems, chimpanzee performance on the reversal-nonreversal shift problem was investigated in the present experiment.

CHAPTER II

METHOD

Subjects

The subjects were 12 chimpanzees, ranging in age from 5 to 20 years. None of the animals had been exposed to discrimination learning problems for the past seven years. The animals were housed at the Yerkes Regional Primate Center of Emory University in Atlanta, Georgia. Animals were housed in pairs in a home cage which consisted of one outside and one inside room. Animals remained in the home cage but were separated from their cagemates during testing. None of the animals were food or water deprived during the course of testing. Subjects were randomly assigned to experimental conditions.

Apparatus

The animals were trained and tested on a modified Wisconsin General Test Apparatus (Riopelle & Rogers, 1965), a device specifically designed to be used for presenting visual discrimination tests to nonhuman primates. The apparatus was placed directly in front of each animal's cage for testing. A metal screen prevented the subjects from seeing the objects while the experimenter prepared each presentation of the stimuli. Stimuli were presented on a delivery tray containing two foodwells in which a small chocolate candy serving as reinforcement could be placed. The stimuli covered the foodwells, and the subjects obtained the candy by displacing the proper stimulus object. The stimuli consisted of four plywood cubes varying on two dimensions: Size, large (4 x 4 x 4 inches) or small (2 x 2 x 2 inches); and brightness, white or black. Stimuli used in pretraining consisted of two plywood cubes intermediate in size (3 x 3 x 3 inches) and brightness (gray) to the stimuli used in the actual testing.

Procedure

The procedure generally followed that used by Tighe (1964) with rhesus monkeys. A schematic diagram of the procedure is shown in Figure 4. Subjects were pretrained to displace one of two middle-sized gray cubes to obtain a candy reward. Each subject was given 15 trials of pretraining. On the following day actual testing began. All subjects first learned a discrimination based on a randomly assigned relevant dimension. For half the subjects the relevant dimension in original training was brightness (e.g. black vs. white), and for the remaining subjects it was size (e.g. large vs. small). The subjects were presented 25 trials per day until criterion performance (21 correct trials on one day) was reached. On the following test day, half the subjects were given a reversal shift (same relevant dimension, but reversed response contingencies) while half received a nonreversal shift (new relevant dimension). Following criterion performance on the first shift problem, the subjects were then given the opposite shift problem (that is, those subjects who received the reversal shift were then given a nonreversal shift and vice-versa) on the next day of testing. Criterion on the shift problems was also 21 correct trials in one day.

The general testing procedure followed the standard method used

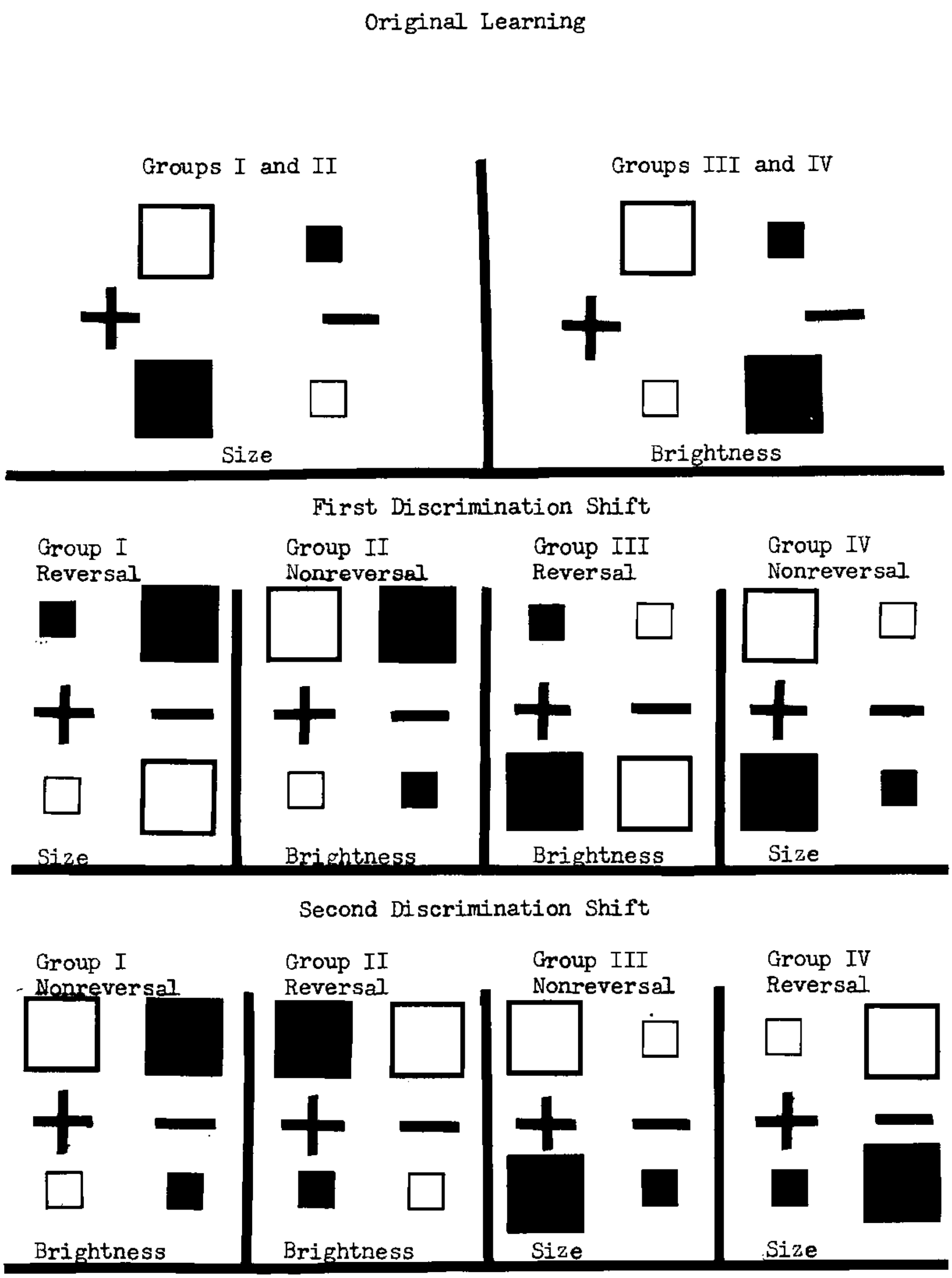

Figure 4. Schematic Diagram of Procedure

with the Wisconsin General Test Apparatus. On a specific trial the experimenter moved the stimulus tray forward while raising the screen between the animal and the stimuli. The subject then displaced one of the two stimuli revealing a chocolate candy on correct choices. After the subject obtained the reward the delivery tray was moved back and the metal screen lowered. If the subject chose the incorrect stimulus object the tray was moved back and the screen lowered immediately. The experimenter then prepared for presentation of the next trial. The order and position of stimuli followed an irregular sequence which provided that the same stimulus pair not appear more than four times in succession and that a correct stimulus not appear more than three times in succession on the same side.

In the test discrimination, (discriminations in which the reversal and nonreversal shift problems were presented) partial reinforcement was controlled by holding the irrelevant dimension constant (Tighe, 1965; Sutherland & Mackintosh, 1971). That is, if size was the relevant dimension in a test discrimination, the irrelevant dimension, brightness, would be held constant by presenting the two black objects together or the two white objects together on a given trial. Thus, the subject would be unable to respond to the irrelevant dimension. Each stimulus dimension was used equally often as the relevant dimension during original learning and the discrimination shifts.

The dependent variable in this study was performance on the discrimination problems. This was measured by the number of errors and the number of days it took each subject to reach criterion.

CHAPTER III

RESULTS

As stated before, two measures of performance, errors and days to criterion, on the original discrimination and the shift problems were analyzed. The mean number of errors in original learning was 27.92, with a standard deviation of 26.44. The mean days to criterion score in original learning was 3.25 with a standard deviation of 2.09. A simple one-way analysis of variance (Kirk, 1968) was performed on the original learning data to determine whether the subjects that received the reversal shift first scored significantly different from the subjects that received the nonreversal shift first. The two groups did not differ significantly on the original learning task with regard to either the error trial scores, $\underline{F} < 1$, or the days to criterion scores, $\underline{F}(1,10) = 1.48$, $p > .05$.

A balanced incomplete block design analysis of variance with repeated measures (Kirk, 1968) was used to analyze the test discrimination data. Between subject effects assessed through this analysis were: Reversal versus nonreversal shift performance; first versus second shift presentation; and shift-presentation interaction. Within group effects assessed were: Relevant dimension in the original learning discrimination (size versus brightness); order of shift within subjects (reversal shift first versus nonreversal shift first); and the dimension-order within groups interaction.

The means and standard deviations for days to criterion scores under each condition are shown in Tables 1 and 2. Table 1 shows the mean reversal and nonreversal shift scores and the mean first and second shift presentation scores. Table 2 contains the mean days to criterion scores for subjects who received either size or brightness as the relevant dimension in original learning, and the mean days to criterion scores for subjects who received a reversal shift followed by a nonreversal shift, and the mean scores for subjects who received a nonreversal shift followed by a reversal shift. The summary table for the analysis of variance on the days to criterion scores is presented in Table 3. The means and standard deviations for the error trial scores under each condition are shown in Tables 4 and 5. Table 4 shows the mean reversal and nonreversal shift scores and mean first and second shift presentation scores. Table 5 contains the mean error trial scores for subjects who received either size or brightness as the relevant dimension in original learning, and the mean error trial scores for subjects who received a reversal shift followed by a nonreversal shift, and the mean scores for subjects who received a nonreversal shift followed by a reversal shift. The summary table for the analysis of variance on the error trial scores is presented in Table 6. All effects were evaluated using the .05 confidence level.

It can be seen that nonreversal shifts were executed significantly faster than reversal shifts in terms of days to criterion scores (nonreversal shift mean = 1.33; reversal shift mean = 3.08), $\underline{F}(1,9) = 178.26$. The error trial scores show similar results: Nonreversal shifts were executed with significantly fewer errors than reversal shifts (nonreversal shift mean = 16.50; reversal shift mean = 42.83), $\underline{F}(1,9) = 62.54$.

Table 1. Means and Standard Deviations of Days to Criterion Scores for Between Subject Variables: Reversal Versus Nonreversal Shift, and First Versus Second Shift Presentation

	Shift Presentation					
	First		Second		Total	
Type of Shift	$\bar{X}$	S. D.	$\bar{X}$	S. D.	$\bar{X}$	S. D.
Reversal	3.50	1.38	2.67	2.13	3.08	1.85
Nonreversal	2.00	2.08	0.67	1.11	1.33	1.80
Total	2.75	1.92	1.67	1.49	2.21	2.02

Table 2. Means and Standard Deviations of Days to Criterion Scores for Within Subject Variables: Size Versus Brightness, and Reversal First Versus Nonreversal First

	Relevant Dimension					
	Size		Brightness		Total	
Shift Order	$\bar{X}$	S. D.	$\bar{X}$	S. D.	$\bar{X}$	S. D.
Reversal First	2.67	1.97	1.50	1.61	2.08	1.89
Nonreversal First	4.00	1.83	0.67	0.47	2.33	2.13
Total	3.33	2.01	1.08	1.26	2.21	2.02

Table 3. Analysis of Variance Summary Table: Days to Criterion Scores

Source	Sum of Squares	df	Mean Square	F
Treatments (unadjusted)[2]	25.79	3	-	-
Subjects (unadjusted)	70.79	11	-	-
Treatments within groups	37.79	3	-	-
Dimension (Size-Brightness)	30.38	1	30.38	7.36*
Order within groups	0.38	1	0.38	<1
Dimension X Order	7.03	1	7.03	1.71
Error within Treatments	33.00	8	4.13	-
Error within Subjects	1.38	9	0.15	-
Treatments (adjusted)	55.97	3	-	-
Shift (Reversal-Nonreversal)	40.46	1	40.46	178.26*
Presentation (First vs. Second)	15.50	1	15.50	68.31*
Shift X Presentation	0.01	1	0.01	<1
Effective Error	-	9	0.23	-
Total	97.96	23	-	-

* - $p < .05$

2 - The experimental design used in this study necessitates confounding the between subject treatment variables, shift (reversal-nonreversal) and order (first versus second shift). The balanced incomplete block design analysis used to assess treatment effects, adjusts the sum of squares for the between subject variables and the appropriate error term to take this confounding into account (Winer, 1971).

Table 4. Means and Standard Deviations of Error Trial Scores for Between Subject Variables: Reversal Versus Nonreversal Shift, and First Versus Second Shift Presentation

	Shift Presentation					
	First		Second		Total	
Type of Shift	$\bar{X}$	S. D.	$\bar{X}$	S. D.	$\bar{X}$	S. D.
Reversal	47.83	24.85	37.83	25.33	42.83	25.58
Nonreversal	23.83	24.98	9.17	10.07	16.50	20.41
Total	35.83	27.66	23.50	24.02	29.67	26.63

Table 5. Means and Standard Deviations of Error Trial Scores for Within Subject Variables: Size Versus Brightness, and Reversal First Versus Nonreversal First

	Relevant Dimension					
	Size		Brightness		Total	
Shift Order	$\bar{X}$	S. D.	$\bar{X}$	S. D.	$\bar{X}$	S. D.
Reversal First	34.67	29.41	22.33	22.93	28.50	27.08
Nonreversal First	51.33	22.17	10.33	5.62	30.83	26.11
Total	43.00	27.34	16.33	17.74	29.67	26.63

Table 6. Analysis of Variance Summary Table: Error Trial Scores

Source	Sum of Squares	df	Mean Square	F
Treatments (unadjusted)	5106.00	3	-	-
Subjects (unadjusted)	11046.33	11	-	-
Treatments within groups	5532.00	3	-	-
Dimension (Size-Brightness)	4266.67	1	4266.67	6.19*
Order within groups	32.67	1	32.67	<1
Dimension X Order	1232.66	1	1232.66	1.79
Error within Treatments	5514.33	8	689.29	-
Error within Subjects	861.00	9	95.67	-
Treatments (adjusted)	10491.36	3	-	-
Shift (Reversal-Nonreversal)	8603.61	1	8603.61	62.54*
Presentation (First vs. Second)	1887.25	1	1887.25	13.72*
Shift X Presentation	0.50	1	0.50	<1
Effective Error	-	9	137.57	-
Total	17013.33	23	-	-

* - $p < .05$

This finding is similar to that of previous studies of reversal-nonreversal shift performance of other nonhuman species. Like rats and monkeys, chimpanzees solve nonreversal shift problems faster than reversal shifts.

It can also be seen that second discrimination shifts were, in general, executed significantly faster than first discrimination shifts, in terms of days to criterion scores (first shift mean = 2.75; second shift mean = 1.67), $\underline{F}(1,9) = 68.31$. Also, fewer errors were made on second shifts than on first shifts (first shift mean = 35.83; second shift mean = 23.50), $\underline{F}(1,9) = 13.72$. This finding suggests that practice on one discrimination problem leads to better performance on a subsequently presented problem. It also appears that this practice effect may be general rather than specific since there was no significant interaction between reversal-nonreversal and first versus second presentation (shift x presentation) in terms of days to criterion, $\underline{F} < 1$, or error trial scores, $\underline{F} < 1$.

The relevant dimension in original learning did have an effect on scores in the test discriminations. Subjects that received size as the relevant dimension in the original learning task took significantly longer to solve the shift problems than did subjects who received brightness as the relevant dimension in original learning (means: Size = 3.33; brightness = 1.08), $\underline{F}(1,8) = 7.36$. Subjects who received size as the original relevant dimension also made significantly more errors than those that received brightness as the original relevant dimension (means: Size = 43.00; brightness = 16.33), $\underline{F}(1,8) = 6.19$. These results suggest that cue saliency did have important effects on discrimination-shift performance in this study.

Order of shift presentation (reversal first versus nonreversal first) did not appear to have a significant effect in this study. Subjects that received a reversal shift followed by a nonreversal shift did not score significantly different in overall performance from those that received a nonreversal shift prior to a reversal shift with regard to days to criterion scores, (reversal shift first, mean = 2.08; nonreversal shift first, mean = 2.33), $\underline{F} < 1$, and error trial scores (reversal shift first, mean = 28.50; nonreversal shift first, mean = 30.83), $\underline{F} < 1$.

There was no significant interaction between the relevant dimension in original learning and order of shift presentation (dimension x order within groups) with respect to either days to criterion, $\underline{F}(1,8) = 1.71$, or error trial scores, $\underline{F}(1,8) = 1.79$.

The ratio of each subject's score on the nonreversal shift problem to his score on the reversal shift problem was used as an index of relative reversal-nonreversal shift performance. A ratio of greater than 1.0 would indicate superior reversal shift performance (lower score on the reversal shift) while a ratio of less than one would indicate superior performance on the nonreversal shift. A ratio of exactly 1.0 would indicate equal performance on both shifts. The nonreversal-reversal shift ratios of error scores ranged from 0.04 to 1.48 with a mean of 0.44. The nonreversal-reversal shift ratios of days to criterion scores ranged from 0.14 to 1.33 with a mean of 0.61, indicating superior nonreversal shift performance in both cases.

Two subject variables, performance on original learning and age, were examined with respect to each subject's relative performance on the reversal-nonreversal shift problems. Correlations between nonreversal-reversal shift ratios and scores on original learning showed that there was no significant relation between reversal-nonreversal shift performance and original learning performance (error trial scores: $\underline{r}$ = -.20, $\underline{t}$ = -.66, $\underline{df}$ = 10; days to criterion scores: $\underline{r}$ = -.29, $\underline{t}$ = -.95, $\underline{df}$ = 10). Correlations between nonreversal-reversal shift ratios and age of the subjects were also computed. Accurate age data were available for only 8 subjects, and so the correlations were based only on those subjects. The 4 subjects whose data are not included in this analysis were classified as being young adults and mature animals. All but one of the remaining subjects also fell into this range. Significant negative correlations were obtained between age and nonreversal-reversal shift performance (error trial scores: $\underline{r}$ = -.83, $\underline{t}$ = -4.94, $\underline{df}$ = 6; days to criterion scores: $\underline{r}$ = -.72, $\underline{t}$ = -3.30, $\underline{df}$ = 6). This finding indicates that performance on the nonreversal shift was relatively better in older animals than in younger animals.

CHAPTER IV

DISCUSSION

The results show that chimpanzees perform better on nonreversal shift problems than on reversal shift problems. Their performance, therefore, is similar to that of other nonhuman organisms (monkeys, rats, chickens), and to that of nursery school children. The mediational model of reversal-nonreversal shift performance (Kendler, 1971) is based, in part, on the finding that nonreversal shift performance is superior to reversal shift performance in nonhuman organisms. Thus, the results of the present study are consistent with the mediational model.

As stated before, mediation in a discrimination reversal problem need not necessarily be based on language. Repeated reversals and overtraining lead to improved reversal shift performance (Harlow, 1949; Dufort, Guttman, & Kimble, 1954). However, the finding that chimpanzees show superior performance on the nonreversal shift supports the notion that human conceptual shift performance is affected by the development of language.

Chimpanzees are capable of communicating at a very sophisticated level using highly complex and abstract symbols (Premack, 1970, 1971, Gardner & Gardner, 1969). However, this capacity is exhibited only in experimental situations involving special training. It would be of considerable interest to see how animals given such training would perform on the reversal-nonreversal shift problem. In humans the actual occurrence of language parallels the development of verbal mediation (Reese, 1962b). Thus the finding that chimpanzees perform better on nonreversal problems is consistent with the notion that verbal mediators affect human conceptual shift performance. This finding also is consistent with the notion that the presence of language affects the basic nature of learning processes.

The finding that nonreversal shift performance was relatively better in older chimpanzees than in younger animals is opposite the trend found in humans, who tend to do relatively better on reversal shift problems as age increases (Kendler, 1971). Such a relationship has not been previously found in nonhuman organisms. Since this relationship has not been reported previously, it is not known whether this finding can be replicated in chimpanzees.

In this study, no significant relationship between original discrimination performance and relative reversal-nonreversal shift performance was observed. This finding contrasts with that of Kendler and Kendler (1959) who reported that fast learners of the original discrimination performed better on reversals relative to nonreversals, while those subjects that were slow learners in the original discrimination did better on nonreversal problems relative to reversal problems. However, later investigators suggested that this finding was due to a confounding of cue saliency effects with reversal-nonreversal shift performance (Heal, Bransky, & Mankinen, 1966; Smiley & Weir, 1966). When cue saliency effects were taken into account by these investigators, there was no relation between original learning and relative performance on shift problems. The findings of the present study agree with this later interpretation.

The finding that test scores differed significantly according to which dimension was relevant in the original learning discrimination suggests that cue saliency does have some effect in this experimental paradigm. This interpretation is consistent with Tighe's (1965) finding that cue saliency did affect both reversal and nonreversal shift performance in rhesus monkeys. Precise interpretation of such a result is difficult in the present study, however, since the relevant dimension was not held constant across successive discrimination problems for a given group of subjects. The repeated measures design necessitates giving each subject three discrimination problems. Since the relevant dimension is not the same in each of these problems, exact interpretation of cue saliency effects is difficult. Nevertheless, cue saliency does appear to affect discrimination performance in this paradigm.

The results also indicate that the animals did better, in general, on the second discrimination shift problem presented than on the first shift problem. This suggests that practice on the first shift problem facilitates performance on the second shift problem. The failure to find a significant interaction between reversal-nonreversal shift and first versus second shift presentation indicates that the difference between reversal and nonreversal shift performance is the same within first and second shift presentations. That is, the difference between reversal and nonreversal shift scores is essentially the same whether those shifts are presented first or following a prior shift. This suggests that practice on the first discrimination shift does not differentially affect reversal and nonreversal shift performance.

In examining the results, it is interesting to note that the data on days to criterion and the error trial data yield identical findings on all effects. This suggests that both are equally sensitive measures of discrimination performance, at least with regard to the paradigm employed in this study.

Finally, it is necessary to introduce a methodological consideration which may affect the interpretation of differences between reversal and nonreversal shift performance. The comparison of results of discrimination shift studies in human and nonhuman subjects may not be entirely appropriate since the methods used in studying human adult subjects have not been the same as those used with young children and nonhumans. In studies of reversal-nonreversal shift performance of young children and nonhumans, the stimuli used varied on only two dimensions and only two stimulus values within dimensions were used (Kendler & Kendler, 1959; Kendler, Kendler, & Wells, 1960). However, when human adults have been studied, multiple dimensions and multiple stimulus values within dimensions have been used (Buss, 1953, 1956; Harrow & Friedman, 1958; Kendler & D'Amato, 1955). It has been shown that increasing the number of stimulus values within dimensions facilitates reversal shift performance (Tighe, 1968). It is reasonable to expect that increasing the number of dimensions on which stimuli vary also affects relative reversal-nonreversal shift performance. Specifically, increasing the number of stimulus dimensions could inhibit nonreversal shift performance because the relevant dimension might become more difficult to select from a greater number of irrelevant dimensions. This confounding of subjects and methods could account for the results obtained in the reversal-nonreversal shift studies. The effects of manipulating number of dimensions and number of stimulus values within dimensions need to be examined.

APPENDIX

Sample Data Sheet

Sensory Modal Transfer I

Subject______________ Condition___________________ Date _________ Page_____

T	O	P	+	-	T	O	P	+	-	T	O	P	+	-	T	O	P	+	-
1	A	R			26	A	R			51	A	L			76	A	L		
2	B	L			27	B	R			52	B	R			77	B	L		
3	A	L			28	A	L			53	B	R			78	B	R		
4	A	L			29	A	L			54	A	R			79	A	R		
5	B	R			30	B	R			55	B	L			80	A	R		
6	A	R			31	B	R			56	A	L			81	B	L		
7	B	L			32	A	L			57	B	R			82	A	R		
8	A	R			33	B	L			58	B	L			83	A	R		
9	A	L			34	B	L			59	A	R			84	B	R		
10	B	R			35	A	R			60	B	L			85	A	L		
11	B	L			36	B	R			61	A	R			86	B	L		
12	A	R			37	A	L			62	B	L			87	A	R		
13	B	R			38	B	R			63	A	L			88	A	L		
14	B	R			39	B	L			64	A	L			89	B	R		
15	A	L			40	B	L			65	B	R			90	A	L		
16	B	L			41	B	L			66	A	R			91	B	R		
17	A	R			42	A	R			67	B	L			92	A	L		
18	B	L			43	A	R			68	A	R			93	B	L		
19	B	R			44	B	R			69	A	L			94	B	L		
20	A	L			45	A	L			70	B	R			95	A	R		
21	A	R			46	B	L			71	A	L			96	B	R		
22	[illegible]	R			47	A	R			72	B	L			97	A	L		
23	A	R			48	A	L			73	B	L			98	B	R		
24	A	L			49	B	R			74	A	R			99	B	L		
25	B	L			50	A	L			75	B	R			100	A	R		

1st 5
+A____
+B____
+R____
+L____

2nd 5
+A____
+B____
+R____
+L____

DATA

Lab No.	Subject Name	Age*	Groups**	Error Trials OL	R	NR	NR/R	Days to Criterion OL	R	NR	NR/R
170	Wenka	20	1	10	91	4	0.04	2	7	1	0.14
192	Su	16	3	3	21	2	0.10	1	3	1	0.33
305	Hook	6	1	8	21	31	1.48	2	3	4	1.33
329	John	12	3	42	65	4	0.06	5	5	1	0.20
333	James	Young Adult	2	0	56	16	0.29	1	4	3	0.75
358	Alice	13	4	21	8	3	0.38	3	2	1	0.50
368	Sonia	15	4	24	17	14	0.82	3	2	2	1.00
406	Cookie	18	3	95	38	4	0.11	8	4	1	0.25
408	Anna	19	1	56	51	10	0.20	6	5	2	0.40
438	Cheeta	Mature	2	33	76	76	1.00	3	8	7	0.88
440	Laura	Mature	4	4	16	4	0.25	1	2	1	0.50
458	Brenda	Mature	2	39	54	30	0.56	4	4	4	1.00

OL - Original Learning

NR - Nonreversal

R - Reversal

NR/R - Nonreversal-Reversal Ratio

* - In Years

** - Groups I and II received size as the relevant dimension in OL. Groups III and IV received brightness as the relevant dimension in OL. Groups I and III received the reversal shift first followed by the nonreversal shift. Groups II and IV received the nonreversal shift first followed by the reversal shift.

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